RL/U/25

ECOLOGICAL STUDY OF CHALK AND LIMESTONE STREAMS

Annual Report
October 1975 to September 1976

University of Reading
Department of Zoology

CONTENTS

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INTRODUCTION

1.1 OBJECTIVES

The report gives a brief synopsis of work carried out during the third year of a four year ecological study sponsored jointly by the Thames Water Authority and the Central Water Planning Unit. It assumes some familiarity with the investigation carried out on the River Lambourn during the preceding three years (see Lambourn Report 1970-1973) which was sponsored jointly by the Thames Conservancy and Water Resources Board (immediate predecessors of the present sponsoring organisations). The present study incorporates, three main objectives which were reassessed at a progress meeting held in March 1976. At that time Thames Water Authority believed that a serious water shortage was imminent and that it would be of considerable value to document the ecological consequences of the drought, and assess the impact of the groundwater scheme if it came into operation. This increase in the work load could be partially offset by the fact that the need for an investigation of a limestone stream lacked urgency at that point in time. It was therefore agreed that additional studies should be carried out on the River Lambourn and Winterbourne Stream instead of starting studies on a limestone stream. The revised objectives are as follows:

a) A detailed ecological study of the River Kennet and its tributaries above Kintbury to provide baseline data in relation to the second phase of the Thames Water Authority's groundwater pumping scheme.

b) An examination of a number of widely separated sites on several chalk streams concurrently to determine whether the data obtained for the Lambourn and Winterbourne are representative of the study areas only.

c) Further detailed studies on the River Lambourn and the Winterbourne to assess the impact of low flows, pumping tests and the operation of the groundwater scheme.

1.2 MODIFICATION OF THE PROGRAMME

The field work in the comparative study of chalk streams (objective b) which involved detailed studies on macrophytes and

invertebrates at eleven separate sites on six rivers was successfully completed during the 12 month period April 1975-April 1976. However;, this was only possible by accumulating a considerable backlog of invertebrate samples for processing including those taken on the River Kennet at Littlecote and Savernake (objective a). The two year study on the macrophytes and fish populations of the River Kennet was carried out as planned, but it was decided to limit examination of the invertebrate samples to those taken in June and December 1975 in line with those being examined for the comparative study.

It has always been our policy to collect more invertebrate samples than we needed to fulfill the basic aims of the project. This makes it possible to select for examination the samples taken at times which later turn out to be of special interest. In the first project on the River Lambourn (1970-73), invertebrate samples had been taken on two study sites monthly between March 1970 and February 1971 followed by a surveillance programme in which the sampling routine was repeated at regular intervals during 1972 and 1973. By the end of the first project in October 1973 laboratory processing of the 1970-71 invertebrate samples was complete., but only selected samples had been examined from later collections. 1973 was marked by a moderate drought and the sponsors requested further information on the manner in which the flora and fauna responded to these conditions. This we have been able to do because the samples had been collected and stored.

During 1974 and 1975 a surveillance programme was retained on the River Lambourn at Bagnor by monthly mapping of the macrophytes and twice yearly (June and December) sampling of the invertebrate community on all habitat types on both study sites. This was essential, not only to put the more limited (two years) studies on the River Kennet in context but also to have a long-term study site against which to compare findings obtained in the comparative study of chalk streams. The substantial field work resulting from the Kennet and comparative studies meant that progress with the analysis of the invertebrate samples from the Lambourn at Bagnor was a low priority, but in 1975 the importance of this aspect of the work became more apparent. Preliminary results suggested that the invertebrate fauna was affected either directly or indirectly by a year of low discharge and since

the drought of 1973 later gave way to very high discharge in 1975, the importance of maintaining continuous records on the Lambourn became clear.

These factors have produced a situation in which it has become necessary to examine more invertebrate samples than we might otherwise have done. Since this is a very time-consuming task it has considerably increased the work load of the team. In order to continue the surveillance programme on the Lambourn and also clear the backlog of invertebrate samples it was necessary to request additional assistance.

1.3 STAFF

Between September and December 1975 the size of the team increased by five graduates who held temporary posts resulting from a supplementary contract to study ecological aspects of a pumping test in the Upper Lambourn. Pumping occurred during September, October and November 1975 and follow-up studies continued well into 1976. Three of the graduates were therefore employed between January and March 1976 to complete the field and laboratory studies. Details of this study are being reported separately.

Mr Cropper took up his post on 1 October as indicated in the previous report. Following our request for additional assistance to help process the invertebrate samples, Miss Comiskey and Miss Rey, who had both gained experience on invertebrates during the pumping test, were recruited to the main project in April 1976.

At the British Ecological Society Winter Meeting held in Cardiff in January 1976 Miss Ham contributed a paper on 'The growth and recession of chalk stream macrophytes' and Dr Wright gave a paper entitled 'An assessment of the invertebrate communities of a chalk stream'. The University celebrated its 50th Anniversary in 1976 and members of the team prepared and manned exhibits on the project on Open Days in March and June for schools and the general public respectively.

Mr G. P. Green submitted his thesis entitled 'The food and production of the bullhead, *Cottus gobio* L., in the River Lambourn' during the year and was awarded the degree of PhD in January 1976.

In August, Mr C. M. Drake attended the 6th International Symposium on Chironomidae held in Prague, Czechoslovakia. Mr G. T. Paton has completed his studies on mayflies and left the team in September 1976. He is now attending a postgraduate course in the Education Department.

1.4 LABORATORIES AND EQUIPMENT

The addition of Miss Comiskey and Miss Rey to the team has increased our personnel but the office and three small research laboratories still offer adequate, if slightly cramped, accommodation.

The field programme retained its wide scope until April 1976, when the comparative study of chalk streams and the two year examination of the River Kennet were completed. This coincided with the end of observations on the pumping test in the Upper Lambourn and field work decreased considerably. During summer 1976, the team made regular journeys to the Lambourn and Winterbourne, but the research students maintained their studies at Littlecote and Savernake. The Land Rover and Crewbus were therefore used more extensively during the first six months of the year, when they covered almost ten thousand miles as compared with just over six thousand miles between April and September 1976. The cost of maintaining the vehicles continued to rise, particularly in the case of the Land Rover, which needed a number of substantial repairs this year, but nevertheless the vehicles gave good service. River Laboratory vehicles and private cars were necessary to enable field work including mapping on the Bere Stream and River Wylye and electric fishing on the Kennet, Lambourn and Winterbourne to run smoothly. In all, the total mileage for the year, including all vehicles, amounted to over twenty thousand miles.

The only major item of equipment purchased was an additional binocular microscope which became necessary with the expanded size of the team.

Mr Drake's programme of field work for the spring of 1976 was in danger of being restricted by the travelling time involved and it was clear that laboratory facilities alongside the River Kennet at Littlecote would enable him to carry out a more ambitious programme. The Geology Department kindly agreed to the loan of a small

caravan for use as a temporary field laboratory and, after minor modifications made by the Zoology Department workshop, the caravan was kept at Littlecote between March and September 1976.

1.5 ACKNOWLEDGEMENTS

We are again indebted to several members of the staff of the Thames Water Authority and the Central Water Planning Unit for help with various aspects of the project. We are also grateful to the Southern Water Authority and the Wessex Water Authority for allowing us to co-operate with their own biological studies on the Candover Stream and the River Wylye respectively. Mr P. Soulsby (SWA) and Mr J. H. Greenwood (WWA) provided valuable help and Major J. C. Walker (Sutton Veny House) kindly allowed us continued access to our site on the River Wylye at Norton Bavant.

On the Lambourn, the Piscatorial Society and Mr J. Gladstone (Donnington Grove) have continued to allow us regular access to the sites at Bagnor. Similarly, Mr G. Wallis and Mr F. Stallwood kindly allowed us to continue our work on the new study site at Weston. Mr J. Liddiard, who had agreed to our setting up a study site at East Shefford during the pumping test on the Upper Lambourn boreholes, allowed further access in late August and September 1976 when operational pumping took place from the Great Shefford and Upper Lambourn boreholes. We are also grateful to several landowners for continued access to the Winterbourne.

On the Kennet we are indebted to the Littlecote Estate and the Savernake Flyfishors for continued access to our major sampling sites. Mr D. M. Brook, the agent for Littlecote Estate, gave practical advice to enable Mr Drake to establish his temporary field laboratory on the Estate during the spring and summer of 1976. Once again we have received valuable co-operation from the respective keepers, Mr D. Macer-Wright at Littlecote, and Mr D. Lofts and Mr G. Hounslow at Savernake. Mr R. D. Lawson has continued to help us in various ways both at Bagnor and at Savernake.

On the Dun we are grateful to the Hungerford Town Fishery for access to their water and to Mr E. L. Davis and Mr D. Macey for their co-operation at this site.

Professor P. Allen (Geology Department) kindly lent a caravan as a field laboratory and his Chief Technicians Mr G. E. Hooks, gave practical help on a number of occasions. Mr J. R. Coundon and his staff in the Zoology Department Workshop have rendered many small services to the team during the year, particularly in the provision of field equipment.

The Freshwater Biological Association has again supported the project by providing access to the study site on the Bere Stream, laboratory facilities in the River Laboratory at East Stoke, assistance in the field and transport. As before, most of the work on the Wylye and the Bere Stream has been carried out by Mr Rufus from the River Laboratory. Without this help it would have been extremely difficult to complete the 12 month programme up to April 1976.

2. RESEARCH PROGRAMME

2.1 GENERAL REVIEW OF FIELD PROGRAMME

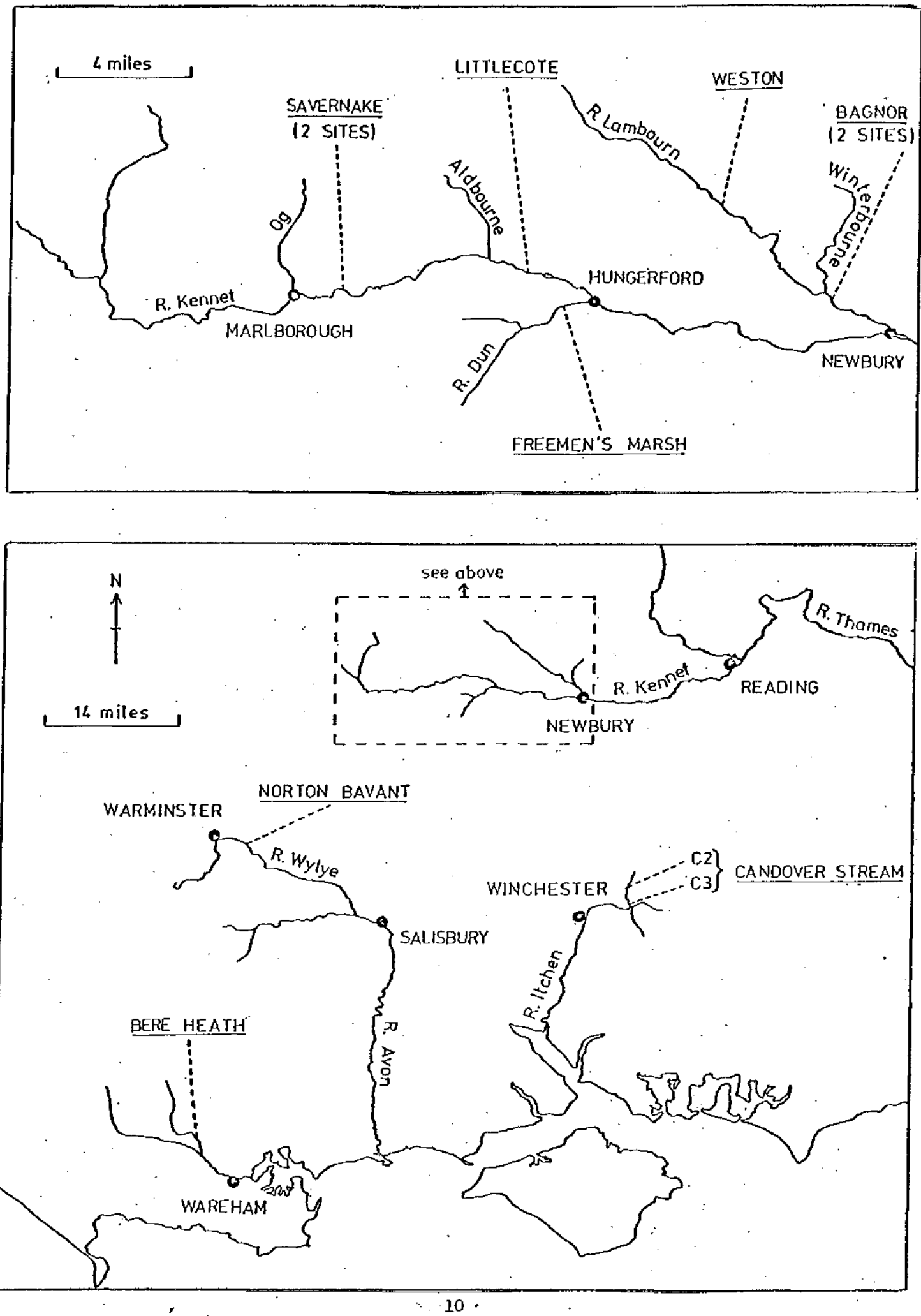
The past 12 months have seen the completion of field work on two major aspects of the programme, namely the two year study of the River Kennet at Littlecote and Savernake (April 1974 - April 1976) and the one year programme to compare eleven sites on six different chalk streams (April 1975 - April 1976). Maps showing the sites are presented in Figure 1. The original intention to carry out preliminary investigations on a limestone stream covering the period April 1976 to April 1977 was abandoned in favour of more detailed studies on the River Lambourn and Winterbourne Stream. These include a) assessment of the impact of the prolonged drought experienced during the summer of 1976, b) observations linked to a pumping test of the Winterbourne group of boreholes (July 1976) and c) operational use of these boreholes together with those in the Great Shefford and Upper Lambourn groups from late August 1976 onwards.

Test pumping of the Upper Lambourn group of boreholes between September and November 1975 was also studied both during and after the pumping phase and is the subject of a separate report.

The field programme therefore occupied a high proportion of the time between October 1975 and April 1976, but since then it has contracted, as planned, enabling more effort to be concentrated on the processing and analysis of the samples and data.

The decreasing discharge experienced in the autumn of 1975 coupled with the fact that the springs failed to break in the winter of 1975-76 meant that it was possible to sample the Kennet at Littlecote and Savernake without interruption. This contrasted with the previous winter when high discharge and turbidity disrupted the macrophyte, invertebrate and fishing programmes for varying periods of time. However, plans to supplement information obtained in spring 1975 on the longitudinal zonation patterns of invertebrates in the Aldbourne, Og and Kennet above Marlborough were thwarted by the dry winter of 1975-76. Substantial sections of these streams remained dry throughout the spring and summer of 1976. Examination of the patterns of

Figure 1. Location of sampling sites discussed in the text



recolonisation of these streams if the springs break in the winter of 1976-77 would be of considerable interest in assessing the effect of the drought and the time required for recovery.

On the River Dun in Freemen's Marsh, electric fishing took place in October 1975, comparable with the 1971 fishing and detailed sampling for invertebrates was carried out in December 1975 as part of the comparative study on chalk streams. However no further detailed work on macrophytes, invertebrates or fish was undertaken after April 1976, in line with policy on the Kennet at Savernake and Littlecote.

The second half of the 12 month comparative study of chalk streams (October 1975 - April 1976) kept to the plan of organisation set up at the beginning of the programme. Monthly mapping of the study sites on the Bere Stream and River Wylye was carried out from FBA Wareham whilst Southern Water Authority mapped their own two study sites on the Candover Stream. The team at Reading were responsible for mapping the remaining six sites monthly and in addition., mapping the study site at the River Dun before invertebrate samples were taken in December 1975.

Weekly samples of pre-emergent mayflies at Bere Stream and the River Wylye were taken from Wareham. Similar samples at site C2 on the Candover were taken by Southern Water Authority and the Reading team collected from Bagnor and Weston on the River Lambourn, Littlecote and Savernake on the River Kennet and Freemen's Marsh on the River Dun. These samples were all sorted, identified and counted at Wareham.

The third element in the comparative study of chalk streams was the December 1975 assessment of the invertebrate communities on the major habitats of each of the eleven study sites. Due to the low rainfall in the second half of 1975, discharge was lower in December than in June 1975, thus easing the practical problems involved in the collection of approximately 200 quantitative samples at our widely spread sites in southern England. Favourable weather during the early part of the month also helped the field procedures and by Christmas all samples had been obtained and the preliminary laboratory treatment and preservation was complete.

A summary of the programme of field work undertaken by the two research students can be found in section 2.6.

2.2 STUDIES ON THE RIVER LAMBOURN AND WINTERBOURNE STREAM

2.2.1 General

Intensive studies were carried out on the River Lambourn at Bagnor, Weston and East Shefford, coupled with longitudinal surveys along the River Lambourn and Winterbourne Stream (See Table 1 for details). The programme was designed to examine some of the ecological effects of the Upper Lambourn (autumn 1975) and Winterbourne Group (July 1976) pumping tests, the drought of 1976 and the operational phase of the groundwater scheme (August 1976 onwards).

The Winterbourne group of five boreholes was tested between 5 and 26 July 1976, when the pumped water was discharged into the Winterbourne Stream at the major outfall immediately upstream of Bagnor gauging weir. In practice, each borehole was tested separately, and at any one time discharge was limited to a constant rate test of one borehole plus very occasional step testing of a second borehole before that was subjected to a constant rate test and the first borehole turned off. Less than one month after completion of this test, the groundwater scheme came into operation and three groups of boreholes were turned on in the Lambourn valley as follows:

Winterbourne Group	23 August 1976
East Shefford Group	26 - 27 August 1976
Upper Lambourn Group	31 August - 1 September 1976

At the end of September the boreholes were still being pumped.

Since the pumping test of the Winterbourne group and its subsequent operational use could alter both the temperature and flow regime of the two study sites on the River Lambourn at Bagnor, the arrangements for recording these physical factors were expanded. A thermograph was installed in the major outfall of the Winterbourne group of boreholes and the Winterbourne Stream thermograph was re-sited above the outfall so that stream and outfall temperature regimes could be recorded separately. The River Lambourn thermograph upstream of the confluence with the Winterbourne Stream was retained in position,

TABLE 1 Studies on the River Lambourn and

DATE	R. LAMBOURN AT BAGNOR		DETAILED ADDITIONAL THE R.
	Macrophytes	Invertebrates and Fish	Weston
OCT 1975	Mapping shaded & unshaded sites	Electric fishing for trout & grayling at 3 population sites & Farm site. Bull-head fishing at 2 sites.	Mapping
NOV	Mapping		Mapping
DEC	Mapping	Quantitative invertebrate sampling on both sites	Mapping & quantitative invertebrate sampling
JAN 1976	Mapping		Mapping
FEB	Mapping		Mapping
MAR	Mapping (2 methods)		Mapping
APR	Mapping (2)	Quantitative invertebrate sampling on both sites	Mapping
MAY	Mapping (2)		Mapping
JUNE	Mapping (2)	Quantitative invertebrate sampling on both sites	Mapping
JULY	Mapping (2)		Mapping
AUG	Mapping (2)	Quantitative invertebrate sampling on both sites (pre-pumping)	Mapping
SEPT	Mapping (2)		Mapping

the Winterbourne Stream, October 1975 to September 1976

STUDIES ON SITES. ON LAMBOURN East Shefford	LONGITUDINAL STUDIES ON THE R. LAMBOURN	WINTERBOURNE STREAM
Studies on macrophytes & invertebrates during & after pumping test of the Upper Lambourn group of boreholes - see separate report	Survey of all sites between Weston & Lambourn Village during & after pumping test of the Upper Lambourn group of boreholes - see separate report	Bullhead fishing at 1 site near Kimbers Cottage
	Survey of all sites & qualitative invertebrate sample from each site remaining wet	Survey & qualitative invertebrate samples from each site remaining wet
	Survey & sample	Survey & samples
	Survey & sample	Survey & samples
	Survey & sample	Survey & samples
Mapping & quantitative invertebrate sampling (pre-pumping)	Survey & sample	Survey & samples. Fishing programme to assess trout population
Mapping & quantitative invertebrate sampling (during pumping)	Survey & sample	Survey & samples

but a second instrument was installed below Bagnor Bridge at which point Lambourn and Winterbourne and outfall water would be fully mixed. In addition to discharge data for the Winterbourne at the Bagnor gauging weir and for the River Lambourn at the Shaw gauging weir current metering was carried out on a weekly basis at two points at Bagnor above the shaded and unshaded sites respectively. This reduced uncertainties about the precise discharge regime experienced by each site due to possible alteration of hatches connecting the two channels of the River Lambourn in the Bagnor area. The current metering stations were set up by Thames Water Authority staff, who carried out the initial metering before instructing team members in the appropriate methodology. Subsequently, the current metering was carried out on alternate weeks by Thames Water Authority and Reading University in order to share the work load.

Finally, detailed surface current readings were made over both sites at Bagnor before and after operational pumping began at the end of August to record the conditions under which the pre-pumping quantitative samples were taken (19 August 1976) and the conditions to which the flora and fauna were exposed when pumping started.

2.2.2 Bagnor

Mapping of the shaded and unshaded study sites at Bagnor took place monthly throughout the year to assess changes in the proportions of the different habitat types. Although discharge was not exceptionally low by December 1975, the springs failed to break in the early months of 1976 and it then became apparent that a drought situation was developing. From February 1976 onwards the area of silt increased considerably on both sites and by May (42% on shaded) or June (35fi on unshaded) the percentage cover of silt was higher than at any time since mapping started in March 1971. On the shaded site the increase in area of silt was in part the result of loss of *Berula,* which occupied a smaller area of river bed in May 1976 (21%) than at any time since March 1971. However, from June 1976 onwards *Berula* rapidly recolonised and by September had reached 49%. Thus, recovery of the species started naturally in June, although it may have been influenced later by the increased flow resulting from the Winterbourne

group pumping test (5-26 July) and operational pumping from 23 August onwards. On the unshaded site, the *Ranunculus* was covered with a thick layer of diatoms and associated detritus which held back growth so that no increase in area of weed took place before mid-June. The *Ranunculus* then began to grow again despite the steadily decreasing discharge. Once started, growth was spectacular and between the beginning of June and August the area on the unshaded site increased from 36% to 70%. It is probable that the Winterbourne group pumping test favoured growth through an increase in discharge, but observations indicate that this factor was not responsible for initiation of growth.

Since March 1976 two mapping methods have been used each month on both sites at Bagnor to assess their comparability. The rapid mapping method which simply records the habitat type at the intersections of a 1 metre grid throughout the 50 m site has been used monthly since March 1972 to obtain information on percentage cover of the habitat types with the minimum expenditure of time in the field. The more complex mapping technique used in the comparative study of chalk streams involved recording the dominant plus accompanying habitats in 100 x 50 cm rectangles throughout the site and, whilst it took longer to carry out, the data were amenable to more detailed analysis. Both mapping methods will be continued until March 1977 before a decision is made on their relative merits.

A full sampling programme for invertebrates on the five habitats at each of the two sites was carried out in December 1975 and June 1976 as part of the longterm programme. These samples, along with similar series taken in 1974 and 1975 were given high priority in view of the need for information on the way in which the invertebrate community responds to conditions of low discharge. All samples were sorted and analysed during the summer and a synopsis of the preliminary findings is given under section 2.5.2. Additional samples were taken in April 1976 in case the pumping scheme came into operation in early summer, but in fact it did not do so until late August. Immediately prior to this complete sets of samples were again taken at both sites at Bagnor and these can provide information on the state of the invertebrate community when dis-

spectacular natural rip-out such that by the beginning of June there was only 1% *Callitriche.* By August even this had disappeared and there was no sign of re-growth by September. The reason for the rip-out of weed between May and June is unclear. It could be due to scenescence of plants which had escaped partial rip-out in the winter or to loss of anchorage to a stable substratum as a result of deposition of large amounts of silt. Whatever the underlying reason for this loss of *Callitriche*, it is clear from observations at Weston, East Shefford and Bagnor that, under the conditions of very low discharge observed in summer 1976, *Callitricha* was not favoured to the detriment of *Ranunculus* or *Berula.*

Detailed studies on the East Shefford site not only covered the Upper Lambourn group pumping test from 1 September to 5 December but extended to the end of April 1976 to observe post-pumping effects on the site. Discharge dropped substantially at the end of the test and because the springs failed to break, the site had undergone marked changes by the end of April 1976. On 8 December 1975 over 90% of the river bed was *Ranunculus* (59%) and *Callitriche* (32%) with only 5% silt, but by 27 April 1976 this was reduced to 37% macrophytes (37% *Ranunculus* and 0.3% *Callitriche)* and 55% sit. The rapid loss of almost all *Callitriche* under conditions of low flow and deposition of silt was of particular interest because of the similar observation at Weston in early summer. *Ranunculus* survived more effectively in the upper part of the site where the stream was narrow and fast flowing, thus limiting the deposition of silt.

The East Shefford site was next mapped on 23 August 1976 just prior to the operational pumping. By then the actual source of the River Lambourn was within the study site itself and only the lower 35 m contained water. Silt occupied over 95% of the substratum and only very small patches of *Ranunculus* and *Callitriche* were observed on the site. Quantitative samples were taken for invertebrates on silt and further qualitative pond net samples taken to provide a list of species surviving on the site. On 7 September, when both groups of boreholes had been operational for approximately one week, the site was re-mapped. The increase in discharge led to a widening of the stream, removed much of the silt (then only 27%) and exposed

gravel (40%) in addition to flooding marginal vegetation, including *Rorippa, Callitriche* and other species. Quantitative samples were taken on gravel to determine which members of the fauna had survived the increased discharge. A monthly programme of mapping will continue during pumping and also into the post-pumping phase to determine the time taken for the macrophyte and invertebrate communities to re-establish themselves.

During and after the Upper Lambourn Group pumping test, regular observations were made at a. number of sites between Weston Farm and Lambourn village to record the impact on the macrophytes and invertebrate communities. A photographic record of the river was also obtained during this period. From April 1976 onwards a new longitudinal study of the Lambourn was initiated to obtain the maximum amount of information on the drought and subsequent implementation of the groundwater scheme, A similar survey had been undertaken monthly between March and December 1974 at 17 sites along both the perennial and intermittent sections of the river to assess the applicability of the detailed work undertaken at Bagnor. The 1974 survey concentrated attention on the growth patterns and distribution of the macrophytes, but in 1976 the survey was extended to include a qualitative survey of the invertebrates. All the 1974 survey sites which contained water were included but because of the drought a number in the intermittent section remained dry through the summer.

2.2.4 Winterbourne

A regular monthly survey of the Winterbourne Stream was also started in April 1976 in response to the need for detailed comparative work over the period of the drought. In 1972 a very comprehensive survey of the invertebrate fauna took place which provided detailed information on the longitudinal distribution of invertebrates in both the perennial and intermittent sections of the stream during a year when the discharge regime was neither unusually high nor low. In April 1976 the intermittent section of the stream was dry and since then the actual source has been retreating down the valley.

When the monthly survey commenced in April 1976 only sites 1-5 in the perennial section were flowing (see Lambourn Report 1970-73

for details of survey sites). Four timed pond-net collections for invertebrates were made at each site as in 1972. In addition notes were taken on the macrophytes present and a photographic record of each site obtained from a standard reference point. By August 1976 sites 5 and 4 had both dried out and site 3 at Honey Bottom was heavily silted.

The annual electric fishing operations for bullheads (October 1975) and trout (August 1976) are also instructive in illustrating the impact of the drought. In October 1975 the bullhead site at Kimbers (between sites 5 and 6) was still flowing and yielded a high density of fish (14 m^{-2}) as in the previous year. In August 1976 the stream had dried to a point upstream of Honey Bottom just short of the road bridge (i.e. below site 4). Fishing began above the duck flighting pond and only 25 trout (including seven 0+ fish) were caught up to the source. In view of the low catch a 'recapture' fishing was considered unnecessary. This catch compares with a total of 141 trout (including 24 0+ fish) caught during the 'mark' fishing in August 1975, when the stream was fished upstream to Kimbers. The low numbers of trout found in the Winterbourne Stream in 1976 recall the position in the previous drought year of 1973 when the 'mark' fishing above the duck flighting pond yielded 40 trout (including 23 0+ fish).

The pumping test of the Winterbourne Group of boreholes between 5 and 26 July 1976 resulted in the addition of pumped water to the stream at the major outfall just above Bagnor gauging weir, which comes at the upper limit of site 1. Hence, increase in discharge due to the pumping test, and subsequently to the operation of the pumping scheme from 23 August onwards could only be observed on the lowest site. The pumping operation resulted in the drawdown of the water table in the upper part of the Winterbourne valley and affected the rate at which the source of the stream moved down the valley, thereby influencing survey sites upstream of the outfall.

2.3 STUDIES ON THE RIVER KENNET AND ITS TRIBUTARIES

2.3.1 Littlecote

By October 1975, the discharge of the River Kennet was declining and this continued throughout the winter accompanied by falling water levels and decrease in area of river bed. Consequently the final seven months of detailed studies at Littlecote (Table 2) offered stark contrast to the previous winter when high discharge and turbidity caused some disruption to the programme.

Ranunculus achieved a maximum cover of 84% in August 1975 and dropped to 57% as a result of some rip-out in October. The percentage cover decreased only marginally over the winter, leaving 54% in April 1976. In practice, since the area of the river bed decreased during

TABLE 2. Sampling programme at Littlecote - October 1975 to April 1976

DATE	MACROPHYTES	INVERTEBRATES	FISH
OCT 1975	Mapping of 100 m site	Quantitative sampling programme	Electric fishing for trout 8 grayling. Bullhead fishing at 2 sites
NOV	Mapping		Stocking of 50 brown trout prior to Dec. electric fishing
DEC	Mapping	Quantitative sampling programme	Electric fishing for trout & grayling
JAN 1976	Mapping		
FEB	Mapping	Quantitative sampling programme	Electric fishing for trout & grayling
MAR	Mapping		
APR	Mapping	Quantitative sampling programme	Electric fishing for trout & grayling

this time these figures represent a decrease in actual area from 674 m^2 in October to 530 m^2 in April. In the previous winter high discharge and turbidity contributed to a more substantial loss from 57% (702 m^2) in October 1974 to 36% (486 m^2) in April 1975. Although the two year study ended in April 1976, the discharge regime was so low that photographs of the site were taken from time to time during the summer to record the major events. The normal increase in area of *Ranunculus* from May onwards failed to occur and the weed was smothered by an abundant growth of epiphytic diatoms and associated detritus. In July 1976, when much of the river bed would normally be covered with *Ranunculus* (71% in 1974 and 74% in 1975) an additional mapping operation revealed that a mere 16% (150 m^2) was present and 72% of the bed was bare gravel. It was also noteworthy that whereas a maximum value of 4% silt had been recorded during the two year period of intensive investigation, 12% of the site was now silt. Visual observations indicated that the *Ranunculus* showed some growth in late summer as observed on the River Lambourn at Bagnor but no quantitative data are available.

The bimonthly quantitative samples of invertebrates on gravel and *Ranunculus* were taken without interruption between October 1975 and April 1976. Samples taken in December 1975 will be analysed as part of the comparative study on chalk streams, but as indicated in the introduction to this report, the remaining samples will not be given high priority.

The electric fishings in October and December 1975 yielded more grayling (43 and 57 fish respectively) than trout (33 and 52) but the reasons for the higher numbers of both species in December are likely to be different. Fifty brown trout (approximately 9-10") were stocked into the fishing site before the December fishing but, being unmarked, their contribution to the total of 52 fish cannot be assessed precisely. Of the 57 grayling taken in December, 44 were 0+ fish compared with 11 0+ fish in October. It has generally proved difficult to stun 0+ grayling in October and it is possible that by December they are more susceptible to the electric field. Alternatively, population movements into the site or simply increased vulnerability due to falling water levels may have contributed to the

high catch of small fish. By February and April 1976 water levels were very low and the numbers of both trout and grayling on the site had shown a decline. In February only 14 grayling (all 0+ fish) and 20 trout (four 0+ fish) were taken, whilst in April there were 19 grayling and 23 trout. Since the 0+ fish caught in February would be placed in 1+ year class in the April fishing there were no 0+ fish in this month. Removal of grayling by the keeper at Littlecote during the early part of 1976 may have contributed to the more drastic decline of this species in February and April 1976.

Electric fishing for bullheads took place in October 1975 on the two sites (gravel and *Ranunculus)* established in October 1974. The high population densities recorded in that year were not maintained and in 1975 the mean density was 2.7 fish m^{-2} on gravel (cf. 5.6 fish m^{-2} in 1974) and 7.1 fish m^{-2} on *Ranunculus* (cf. 14.2 fish m^{-2} in 1974).

2.3.2 Savernake (Table 3)

This sampling area was also subjected to a decreasing discharge regime throughout the period of intensive study. However, river management policy changed during this period, resulting in some substantial alterations to water levels. Whereas the site at Littlecote is fast-flowing and relatively shallow, the two study sites at Savernake are upstream of hatches which, when closed, produce slowly-flowing deep water over the sites. The upstream site, being further from the influence of the hatches, is the more shallow and fast-flowing. In October and November the normal slowly-flowing deep water was maintained, but in December and January the hatches were raised to increase current through the section, and both water levels and total area of river bed decreased on the two sites. However in February the new keeper lowered the hatches and maintained high water levels for the remainder of the period.

On the lower site, *Schoenoplectus* is the dominant macrophyte. In October it occupied 65% of the river bed and by April had only dropped to 57%. During the two years it demonstrated its stability over a considerable range of flow regimes by occupying between 55% and 67% of the river bed. *Ranunculus* (9% in October) showed its normal

TABLE 3 Sampling programme at Savernake - October 1975 to April 1976

DATE	MACROPHYTES	INVERTEBRATES	FISH
OCT 1975	Mapping of Upper & Lower sites	Quantitative sampling programme	Electric fishing for trout at 2 population sites. Bullhead fishing at 1 site
NOV	Mapping 2 sites		
DEC	Mapping 2 sites	Quantitative sampling programme	Electric fishing for trout at 2 population sites
JAN 1976	Mapping 2 sites		
FEB	Mapping 2 sites	Quantitative sampling programme	Electric fishing for trout at 2 population sites
MAR	Mapping 2 sites		
APR	Mapping 2 sites	Quantitative sampling programme	20 April - 55 brown trout stocked. 26 April - electric fishing for trout at 2 population sites

decline through the winter whilst the area of gravel was relatively stable between 18% and 22% from October to April, During this period silt was deposited under conditions of low flow and its area increased steadily from 3% in October to 24% in March and 22% in April. Previously it had only exceeded 10% in October 1974 when 13% was recorded following a weed cut which exposed silt.

Although the mapping programme ceased in April 1976 an interest

was retained in the site due to the unusually low discharge. On 10 June there was good growth of *Schoenoplectus* with many aerial shoots, but no suggestion that it was colonising new areas. There was no sign of *Ranunculus* and the area of silt was still high. In addition *Cladophova* was growing well and showing signs of forming mats in areas where aerial shoots of *Schoenoplectus* broke the surface. In late summer *Cladophora* became a major problem and Thames Water Authority staff had to remove thick layers from the surface every few days. By autumn the blanketing effect of the *Cladophora* was affecting the *Schoenoplectus* and there were few signs of growing weed at the lower site.

On the upper site, where the area of *Schoenoplectus* is lower and *Ranunculus* is an important macrophyte, the sequence of events through the winter was very similar. Late summer growth of *Ranunaulus* resulted in maximum cover of 35% in October but weed was then lost rapidly and none was left by January. *Schoenoplectus* remained relatively stable through the winter, dropping from 27% in October to 23% in April and remaining within the range 29% to 21%. During the two year study the extreme values observed were 13% in July 1974 after a weed cut and 29% in December 1975, again demonstrating a stability not seen in *Ranunculus,* The higher flow regime of December and January on the upper site may have temporarily interrupted the deposition of silt there. Gravel increased from 29% in October to 66% in February and then fell to 18% in April due to silt deposition. Silt occupied 5% of the river in October, 4% in December, then increased to 9% in January and finally to 28% in April, the highest cover ever recorded. The river was clearly experiencing extreme conditions for, during the two year period of study, the previous range for silt was from 1% to 10% after a weed cut, which exposed silt. By 10 June the site had undergone further changes similar in nature to those observed on the lower site. The *Schoenoplectus* had many emergent stems although there were no obvious changes in the area of weed. *Ranunculus* had failed to appear and deposition of silt had occurred over much of the gravel. *Cladophora* had recently started to grow around the stems of *Schoenoplectus* and could also be found on the surface of silt and gravel beds. Later in the season it became necessary for Thames Water Authority to remove large masses of surface *Cladophora* but the *Schoenoplectus* did not

appear to be smothered as badly as on the lower site, and by autumn it was showing some re-growth.

Bimonthly quantitative sampling for invertebrates was possible throughout the winter on each of the two study sites although, as indicated in the section on Littlecote, only samples taken in December are to be given high priority. Both gravel and *Schoenoplectus* were sampled on each site but, in addition, *Ranunculus* was sampled on the upper site.

The electric fishing programme for trout on the two sites at Savernake was also possible throughout the winter due to the lower discharge regime. The catches were low and will yield little information about the population. In both October and December two 04 grayling were taken and these were the only grayling caught at Savernake apart from two mature fish caught in April 1974. In October 1975 a total of 37 trout (of which 11 were 0+ fish) were taken on the lower site but only 23 (11 0+ fish) were caught on the upper site. On the remaining three fishing operations smaller numbers of fish continued to occur on the upper site, which was the shallower of the two and the total numbers of trout taken on each occasion were lower than at any time since the study began in April 1974. In December 1975 the lower site yielded 14 fish (seven 0+) and the upper site 12 (eight 0+) but in February 1976 the lowest numbers ever were obtained with 11 fish (six 0+) on the lower site and four fish on the upper site. On 20 April 1976 a small stocking operation involving 55 brown trout (approximately 12-14'') took place in the vicinity of the two fishing sites. The April fishing took place six days later and obtained a larger catch with 36 fish at the lower site but only nine fish at the upper site. None of the 32 rainbow trout which had been stocked in to the river in July 1975 was caught on any fishing from October to April.

A bullhead survey carried out on the gravel site in October gave a density of approximately 4.5 fish m^{-2} compared with 2.0 m^{-2} in October 1974.

2.3.3 River Dun in Freemen's Marsh

The two major aspects of field work were both successfully carried out in October (fishing operations) and December (macrophyte

and invertebrate sampling programmes). The trout and grayling site yielded 37 trout., the four largest individuals all being rainbow trout, 37 grayling and 13 pike (of which ten were 0+ fish). The numbers of trout and pike were marginally higher than in October 1974, but grayling were much more numerous. The bullhead population was also assessed for comparison with 1974.

The 50 m study site for macrophytes and invertebrates was mapped in December. Quantitative sampling of the invertebrate communities on all the major habitat types (gravel, silt, *Callitriche, Myriophyllum)* was then carried out for inclusion in the comparative study of chalk streams.

2.3.4 The Aldbourne, 0g and Kennet above Marlborough

A brief examination of the winterbourae section of these streams was made in March 1976, when it was found that in each case the springs had failed to break. The Aldbourne was dry at Whitton Ditch, the Og at Gay Bridge and the River Kennet was dry upstream of Manton. Appropriate photographic records were obtained in each case, but plans to augment the basic data on the distribution of invertebrates in these bournes had to be abandoned. The streams remained dry throughout the summer and any assessment of the long-term effects of the drought on the invertebrate communities of these bournes will necessitate a detailed examination after the springs eventually break.

2.4 COMPARATIVE STUDY OF CHALK STREAMS

The field work for this 12 month study which involved the collection of comparable data on the macrophytes and invertebrates of eleven sites on a number of different chalk streams was carried out between April 1975 and April 1976. The plan of organisation adopted for the collection of these data over such a widespread series of study sites was outlined in section 2.1. The programme included a) a detailed monthly mapping procedure on all sites except the River Dun, b) weekly times collections of mayfly nymphs on ten sites (site C3 on Candover excluded) throughout most of the year and

c) a major quantitative sampling programme for invertebrates on all the important habitat types of each study site in both June and December 1975.

The mapping of three sites on the River Lambourn and a further three on the River Kennet is indicated in Tables 1, 2 and 3. Table 4 gives information on the remaining four sites. On completion of this programme in April 1976, no further studies were undertaken on the River Wylye. However, due to the extreme conditions of drought an additional mapping was carried out on the Bere Stream in July 1976 for comparison with the previous year. Mapping of sites C2 and C3 on the Candover Stream by Southern Water Authority continued throughout 1976 as part of their own surveillance programme.

TABLE 4 Mapping and sampling programme on the River Wylye, Bere Stream and Candover Stream (two sites)

DATE	R. WYLYE Norton Bavant	BERE STREAM Bere Heath	CANDOVER STREAM Sites C2 and C3
OCT 1975	Mapping	Mapping	Mapping by SWA
NOV	Mapping	Mapping	Mapping by SWA
DEC	Mapping & invertebrate sampling	Mapping & invertebrate sampling	Mapping by SWA & invertebrate sampling
JAN 1976	Mapping	Mapping	Mapping by SWA
FEB	Mapping	Mapping	Mapping by SWA
MAR	Mapping	Mapping	Mapping by SWA
APR	Mapping	Mapping	Mapping by SWA

Timed collections of mayfly nymphs were made on ten sites on a weekly basis up to the end of November 1975. By then, pre-einergent nymphs of most species were uncommon and the frequency of sampling was reduced to once every two to three weeks for the remainder of the 12 month period. All samples for the ten sites have been examined and the pre-emergent specimens have been identified and counted. Histograms for each species on each site have been drawn up, but detailed comparison of sites with regard to species composition, number of generations, peak emergence periods, etc. has not been undertaken as yet.

The third aspect of the comparative study of chalk streams involved the sampling for invertebrates on all major habitat types of the eleven sites in December 1975. Details of the samples taken are given in Table 5 and indicate that a total of 195 quantitative samples

TABLE 5. Habitats sampled in December 1975 on the eleven study sites (figures indicate number of samples taken)

Habitat Types / Sampling Sites	GRAVEL	*RANUNCULUS*	*CALLITRICHE*	SILT	*BERULA*	*SCHOENOPLECTUS*	*MYRIOPHYLLUM*	*RORIPPA*
R. Lambourn. Bagnor-unshaded	5	5	5	5	5			
R. Lambourn. Bagnor-shaded	5	5	5	5	5			
R. Lambourn. Weston Farm		5	5	5				
R. Kennet. Littlecote	5	5						
R. Kennet. Savernake-lower	5					5		
R. Kennet. Savernake-upper	5	5				5		
R. Dun. Freemen's March	5		5	5			5	
Candover Stream-C2	5	5			5			5
Candover Stream-C3	5	5	5	5	5			
R. Wylye. Norton Bavant	5	5		5				
Bere Stream	5	5						5

were obtained. In most cases, the habitats sampled on a given site were those previously sampled in June 1975. However in a limited number of instances a habitat present in June had been eliminated or was unimportant in December or, alternatively, a new habitat had appeared by December, although absent in June. In all cases, five samples were taken on every habitat of any importance an each site. These samples, together with a further 204 taken in June 1975 give a total of about WO samples which, when examined, will enable us to determine the degree to which the various components of the invertebrate fauna are confined to particular habitat types across a range of chalk stream sites. In addition, by examining the importance of different habitat types throughout the 12 month period, and looking in detail at the invertebrate communities occurring on them in both summer and winter, a more balanced viewpoint can be expressed on the importance to the ecosystem of the various habitats and their accompanying invertebrate fauna.

2.5 PROGRESS IN LABORATORY PROCESSING AMD ANALYSIS OF DATA

The purpose of this section is to indicate where progress has been made with the processing of maps and samples resulting from field work during the year and with reducing the backlog of invertebrate samples taken prior to this year. In limited areas, such as the reading of scales taken from trout and grayling in the River Kennet, samples have been accumulating and still await attention.

The completion of a number of important programmes of field work was of paramount importance during the first half of the year and this left insufficient time for significant progress in the processing of samples. From April onwards, laboratory work became the first priority, particularly with regard to clearing the backlog of invertebrate samples. By the end of September sufficient progress had been made to initiate the collation of these data for the first major analyses of the invertebrate data covering the period March 1971 to June 1976. During the final year of the contract the low level of field work will be maintained to enable the team to concentrate on the remaining samples and permit further analyses on the entire run of data.

2.5.1 Macrophytes

The mapping scheme for the ten sites in the comparative study of chalk streams and the additional site at East Shefford on the River Lambourn resulted in the regular production of maps, normally once a month. All the information on the habitat types occurring on each site is now transferred to computer cards and it is possible to obtain print-out maps and a statement on the percentage cover of each habitat type., within days of the actual mapping operation. In addition, each map is compared in detail with the map for the previous month, thereby giving information on any changes occurring on each 100 x 50 cm rectangle over the entire site. A detailed comparison of the seasonal trends observed on each of the ten sites is yet to be undertaken. However, the pattern of year to year variation observed at the study sites at Bagnor up to l975 has been examined. The mapping results during the extreme drought in the summer of 1976 will be particularly useful in extending our knowledge of the response of the macrophytes to conditions of low flow. Analyses to be undertaken next year will assess whether the flow regime has an overriding effect on the balance of habitat types, despite management practices such as weed cutting, dredging and alteration of hatches, which add further complexity to the dynamics of the system.

2.5.2 Invertebrates

Undoubtedly, the most important problem to be dealt with under the heading of laboratory processing is the elimination of the very substantial backlog of invertebrate samples which accumulated during the period of intensive field work. In April 1976 a target was set of picking, identifying and counting the invertebrates from 431 quantitative samples over the period April 1976 to April 1977. These included 55 samples taken at Bagnor in 1974 and 376 samples remaining from the comparative study of chalk streams, comprising a further 85 from Bagnor, 62 from the Kennet at Littlecote and Savernake and 229 from other streams, all taken in June and December 1975.

In addition to the 431 samples already being stored, 55 further samples were taken on the two sites at Bagnor in June 1976

and an additional 50 samples were due to be taken in December 1976 to continue the long-term studies at this site. Clearly, on the above scheme, these 105 samples could not be examined before May 1977 and would then occupy two members of the team almost full time to the end of the contract in September 1977. However, up-to-date information on the impact of the summer drought was needed to assess whether further samples were required to obtain an adequate record of the response of the fauna to these exceptional circumstances. Consequently the 55 samples taken at Bagnor in June 1976 were examined in place of a similar number in the original 431 samples. These remaining 55 samples will be processed, along with the December 1976 samples from Bagnor, between May and September 1977.

By the end of September 1976 the team had managed to clear 185 samples which is only marginally short of the objective. By mid-October 1976 a run of invertebrate data from March 1971 to February 1972 (monthly) followed by six monthly data for June and December from June 1972 to June 1976 became available and yielded some very stimulating preliminary results which were presented at a Chalk Stream Liaison Group Meeting in late October 1976.

Qualitative invertebrate samples taken monthly along the Winterbourne Stream and the River Lambourn were examined promptly throughout the summer, giving species lists which indicated the prevailing longitudinal pattern of zonation of the invertebrate community. Further analysis of the longitudinal zonation of the invertebrate community along the Winterbourne Stream was carried out on similar data obtained during a one year survey in 1972. Sørensen's quotient of similarity was used to compare the species present at each site and the results were displayed as a dendrogram using Mountford's method. The technique proved successful in displaying major divisions of the invertebrate fauna at points which have significance with regard to permanence of the water, and will be used on the longitudinal survey data being collected along both the Winterbourne Stream and the River Lambourn this year.

2.5.3 Fish

The field work on fish also reduced considerably after April. However, with the major effort directed to processing invertebrate samples, progress with fish material has been delayed. Most of the scales collected since October 1973 have still to be read and this will require considerable effort next year. Good progress has been made with two other aspects. Stomachs were collected from three size groups of trout and grayling at regular intervals during 24 hours in October 1973 to record daily changes in feeding activity. Examination of the contents has now been undertaken and is almost complete. In addition, further time has been devoted to the analysis of data on the age, growth and movements of trout and grayling for 1970-73.

2.6 DETAILED STUDIES ON MAYFLIES AND N0N-BITING MIDGES

Mr Paton's two-year study of mayflies was completed in September. The major portion of his programme of field work took place in 1975 when sites on both the Lambourn (Bagnor) and the Kennet (Savernake and Littlecote) were sampled regularly. During the summer of 1975 sampling took place weekly to ensure that the life cycles of the important species were documented accurately. Sampling was terminated at Bagnor in November 1975 but field work continued at Littlecote and Savernake throughout the winter of 1975-76 and some sampling continued up to June 1976 to give over 12 months' data for these study sites. It was therefore possible to compare the mayfly fauna in a year of high flow (1975) with the fauna in a year of drought (1976). During the winter of 1975-76 frequency of sampling on the Kennet at Savernake and Littlecote was reduced to every two to three weeks. Most of the winter and spring of 1976 was devoted to an examination of the samples obtained during the summer of 1975 to provide satisfactory data on the changes in the density and size structure of the different species on each of the three study sites. Further sampling then took place in summer 1976 to provide specimens for length-weight relationships prior to estimating the biomass and finally the production of the major species.

The response of the mayfly fauna to the severe drought of 1976 was particularly instructive and differed between the two sites on the Kennet. At Savernake, the hatches were lowered to maintain the high water level and this resulted in almost canal-like conditions in the river. Densities of mayfly nymphs were very low during the spring and early summer at this site which was previously noted for its high populations and diversity of species under normal conditions of flow. At Littlecote, however, the river was allowed to flow relatively freely and was undoubtedly faster flowing than at Savernake. Despite poor weed growth, shallow water and a narrowing channels most species of mayfly nymphs maintained their populations in this restricted habitat, helped perhaps by an abundant source of food in the form of epiphytic algae.

Mr Drake completed some preliminary sampling for chironomid larvae in late 1975 before starting a detailed 12 month programme of field work at both Littlecote and Savernake 'early in 1976. In each case, the chironomid fauna of the dominant macrophyte *(Ranunculus* at Littlecote and *Schoenoplectus* at Savernake) is being examined. The main aims of the sampling programme are acquisition of basic data on a) the life cycles of the most important species, b) variation in species composition with habitat and time of year, c) microdistribution on the macrophytes and d) density of larvae.

At Littlecote, ten samples of *Ranunculus* are taken both within and at the upper surface of the weed bed at ten or eleven-day intervals. In contrasts at Savernake, the *Schoenoplectus* is sampled weekly as follows. Ten individual strap-like leaves (or groups of leaves, when density of larvae is low) are taken and divided into 10 cm sections to determine the distribution of the larvae along the stem. Processing of samples from both sites involves identification and counting of all chironomid larvae and larger invertebrates, together with investigations on the quantity and quality of the accompanying detrital/algal complex. Leaf area of *Schoenoplectus* is recorded and the dry weight of *Ranunculus* samples is determined so that the numerical data on chironomid larvae can be related to surface area and dry weight of weed respectively.

The small caravan based at Littlecote gave Mr Drake the opportunity to carry out preliminary field experiments as a prelude to further work of this type in 1977. The growth form of *Schoenoplectus* was simulated by using strips of heavy gauge polythene sheeting. Large numbers of artificial 'leaves' were placed in the river and the process of colonisation by chironomid larvae observed by the regular removal of sets of leaves every two to three days. The method proved to be a valuable experimental approach in simplifying the system by providing a controllable unit. It is to be used in 1977 to refine ideas on the movement of larvae in the river and in assessing spatial factors in the microdistribution of larvae on *Schoenoplectus.*

The programme of emergence trapping at both sites which started in 1975 has been continued on a regular basis throughout the past 12 months, and over 75 species have been identified to date.

The low discharge at both sites during 1976 produced some problems in connection with the sampling programme. At Littlecote much of the *Ranunculus* appeared to be suppressed by a heavy enveloping growth of diatoms and associated detritus. At Savernake summer growth of *Cladophora,* which resulted in a thick surface mat, eventually killed some of the visible *Schoenoplectus* stems. This meant that the precise sampling location for these two macrophytes at each site had to be altered depending on their availability. Data already available for 1976 indicate some pronounced differences in species composition when compared with the pilot sampling programme carried out in 1975.